

Solar measurement / PyranometerApp

App for iPhone, iPad

USER MANUAL

PyranometerAppmanualv1104



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Introduction

Name: Solar measurement / PyranometerApp

Developer: Hukseflux Thermal Sensors / Susan Pesman

Description: measurement of solar irradiance in Watt per square meter (W/m^2)! Gadget for fun and educational purposes only. Provided by Hukseflux Thermal Sensors. Hukseflux is a market leader in high accuracy measurement instruments. With the introduction of this App in iTunes, Hukseflux became the inventor of the "camera+diffusor" measurement principle. Hukseflux would like to receive your comments, and also encourages users to enter their improvements into this app." app@hukseflux.com title "comment app"

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1 User guide

1.1 The first solar radiation / pyranometerApp

Measurement of solar irradiance in Watt per square meter (W/m^2)! The iPhone-App is a gadget for fun and educational purposes only. In daily life measurement of solar radiation is done by highly accurate 'pyranometers'. These instruments are used for measurements of weather, climate, solar energy production, agriculture and other related fields.

The solar radiation / pyranometerApp is provided by Hukseflux Thermal Sensors, a market leader in solar measurement instruments. With the app, our clients, users and other interested people can give a glimpse to family and friends what concerns them in professional life. With the introduction of this App in iTunes, Hukseflux became the inventor of the iPhone "camera+diffusor" measurement principle.

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1.2 Print the 'diffusor'

In order to perform a good measurement of solar radiation, the lens from your iPhone needs to be covered with an enclosed 'diffusor'. You need a diffusor so that the iPhone sees 180 degrees field of view, so the complete sky. The camera without diffusor only has ± 30 degrees, field of view. The diffusor also makes it possible to work at lower light levels, that you will see when using the pyranometerApp indoors.



Figure 1 *diffusor, actual size*

The diffusor can be downloaded from the app and transferred to your e-mail address in order to make it possible to print it on a normal printer. Of course you can use the last page of this manual as well.





Figure 2. *Camera lens of your iPhone or iPad*

1.3 Position diffusor

Position diffusor over the camera lens of your iPhone, iPad, iPod. Via the diffusor placement menu, the camera is activated and so makes it possible to see what you are doing when placing the diffusor properly in front of the lens.

Cut the diffusor with scissors and stick the diffusor to a piece of scotch or similar tape. Press 'diffusor placement' in the menu. The iPhone looks through the lens now and helps you positioning the diffusor this way. Move tape with diffusor over the lens, lower the diffusor. Placement is fine when you see a vague cross (+) with in total four lighter areas towards the edges of your screen. (Figure 5) Press 'done' to return to the main menu.



Figure 3. *Stick diffusor on tape*



Figure 4. Cover lens with diffusor

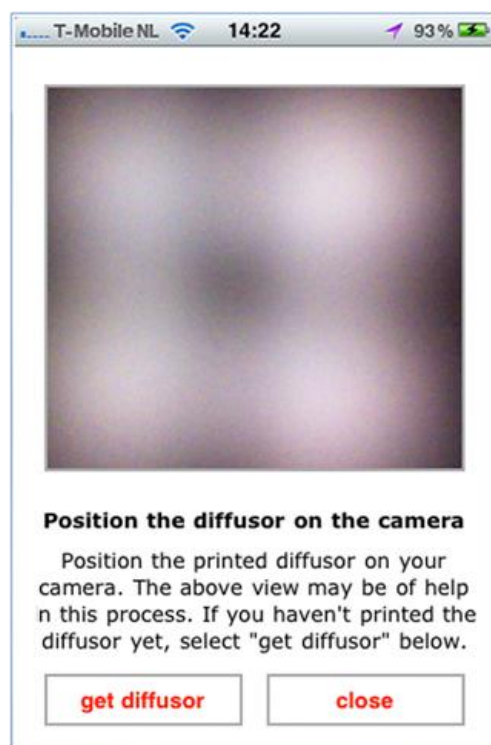


Figure 5. When you see this "cross", you achieved perfect diffusor placement!

1.4 Perform a test-measurement.

Go outside when the sun is shining. Push button "Measure Irradiance". Put the camera in horizontal position facing up. Wait until last beep. Read out measurement. On screen. This value is not yet "calibrated", so it only produces relative values. Perform a measurement with the camera pointed at the sun. The value pointed at the sun should be higher than that of the measurement in the horizontal position.





Figure 6. *Push button 'measure irradiance'*

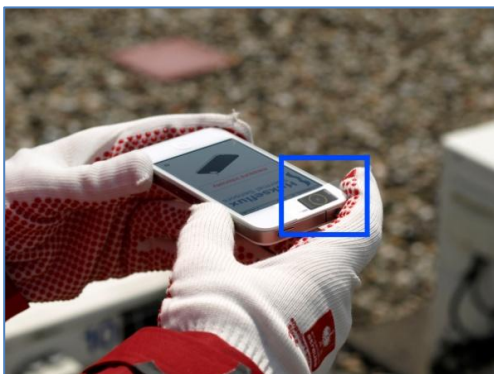


Figure 7. *Do a measurement in horizontal plane*



Figure 8. *Perform measurement tilted towards the sun*

1.5 Improve accuracy via calibration.

Calibration can be skipped when taking a first look at this app, but if the calibration is not performed, the absolute values of irradiance will not be correct (way off!). On a sunny day, look up a local weather station on the internet that measures solar radiation in Watts per square meter W/m^2 . (usually an internet search of "weather station + location + W/m^2 ", for instance "meteo station Amsterdam W/m^2 " will do the job). Preferably wait for a sunny cloudless day around noon, between



11 and 14 hours. Enter calibration menu. Enter current W/m^2 value. Calibrate.

You are also able to enter a calibration constant manually. Most modern versions of iPhones and iPods (2010, 2011) perform reasonable measurements when you enter '10' as a constant.

1.6 Perform a calibrated measurement

Perform a calibrated measurement. As 2.

1.7 Check measurement performance.

Compare measurements in horizontal position to those of a local Weather station for different solar elevations (i.e. different times of the day). Deviations of $\pm 30\%$ can be expected.





2 Links

Link: Scientific background: Wikipedia pyranometer

<http://en.wikipedia.org/wiki/Pyranometer>

Link: Hukseflux thermal sensors/pyranometer

<http://www.hukseflux.com/applications/solarEnergy.html>

Link: Susan Pesman

<http://www.susanpesman.nl/>





3 Educational (suggested experiments)

Experiments with the Pyranometer App (educational).

- Horizontal solar irradiance over a day
Perform a measurement in horizontal position. On a clear sunny day on an average altitude the measured value should peak at around noon (highest solar position) and be lower than that from sunrise to noon and noon to sunset. Maximum value is 1500 W/m^2 . This means that at that moment could power equivalent to three bread toasters from a square meter of solar energy.
- Indoor irradiance order of magnitude
Perform a measurement indoor under only artificial light. You will discover that you only need around 8 W/m^2 to be able to read a book! Lessons learned: Indoor light levels are quite low, compared to outside! The eye adjusts really good!
- Horizontal versus tilted surface irradiance level.
Perform a measurement in horizontal position. Perform a measurement aimed at the sun (photo 5). Compare. The measurement value aimed at the sun should be larger than that in the horizontal position. Solar energy installations are optimized to catch as much sun as possible, typically by aiming them south at an angle depending on the local latitude. (Horizontal at the equator, around between 30 and 40 degrees in most of Europe, the USA, Japan, China).





Figure 9 + 10. *Shading the diffuser from direct sunshine*

- Diffuse versus direct solar irradiance:
Perform a measurement in the horizontal position with the sun shining directly onto the diffuser. Repeat the same measurement; now shading the diffuser from direct solar radiation for example by casting a shadow on it using your hand, please keep at least 1 meter or 3 feet distance (*figure 9*). Also possible is to wait for a cloud passing by! A cloud can also block the direct radiation, leaving the diffuse only. When you subtract the diffuse radiation from the total radiation, you get the direct radiation (horizontal component). Lesson learnt: direct solar radiation is dominant.



4 FAQ

Link: Frequently asked questions about this app.

- My local met station measures sunshine hours; can I use the data for calibration. Answer: No you cannot; the sunshine hour measurement does not represent irradiance.
- My local measurement station measures Btu/square ft. Can I use the measurement data? Yes you can, but you should convert to W/m^2 (look for a site under "heat flux conversion".)
- I cannot find any actual solar radiation data in my neighbourhood, what can I do? Use the printed diffusor and set calibration constant manually to value '10'. Bear in mind that you increase your margin of error. The other possibility, is, wait for a perfect day and compare with a station further away. (200km is OK)
- I have no printer available in order to print a diffusor. As a diffusor you can use a tiny piece of general printing-paper, preferably double. Even when you calibrate, you will not reach the accuracy of the printable diffusor.

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Solar measurement / PyranometerApp, the diffusor:



How to position the diffusor:

Position diffusor over the camera lens of your iPhone, iPad, iPod. Via the diffusor placement menu, the camera is activated and so makes it possible to see what you are doing when placing the diffusor properly in front of the lens.

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Figure 1. Stick diffusor on tape



Figure 2. Cover lens with diffusor

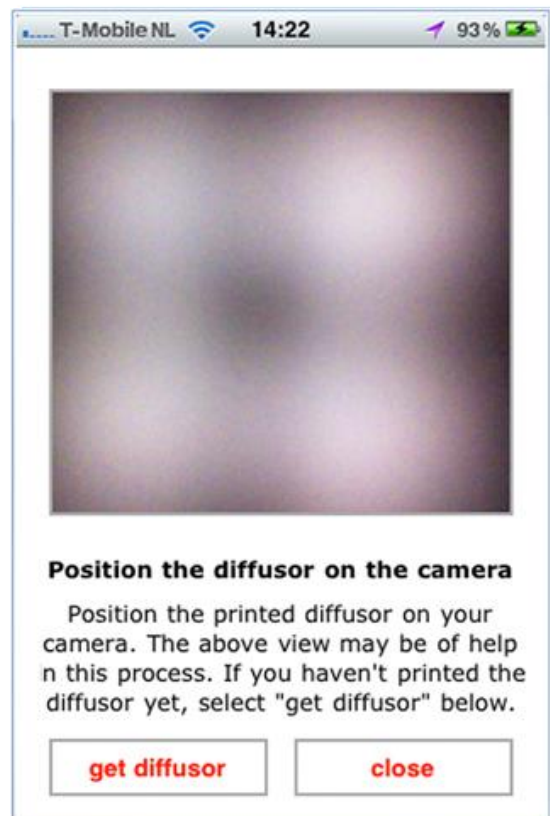


Figure 3. When you see this "cross", you achieved perfect diffusor placement!



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Hukseflux Thermal Sensors B.V. is the inventor of the "camera+diffusor" measurement principle and inventor of the diffusor described in this manual.

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